245-1-0

Analysis of Various Homeowner Gypsy Moth Control Methods

P. 1

by

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Northeastern Area

Forest Service

U.S. Dept. of Agriculture

Broomall, Penn.

I. The Use of Disparlure, the Sex Pheromone of the Gypsy Moth, for Control of Gypsy Moth Population through Mating Disruption

Since 1971, scientists with the United States Department of Agriculture (Agricultural Research Service and the Animal and Plant Health Inspection Service), and with State Cooperators such as the Maryland Department of Agriculture, have been developing a technique for suppressing populations of gypsy moths through disruption of mating communication. The flightless female attracts the male gypsy moth by emitting a chemical, called a sex pheromone, which for this species has been identified as the plus-enantiomer of cis-7, 8-epoxy-2-methyloctadecane, called (+)-disparlure. By dispensing quantities of pheromone throughout the woodlot, the hope is to "confuse" the male, preventing it from finding the "calling" female. The female then remains unmated, lays sterile eggs, and if this process happens to keep most of the females in the population from mating, the gypsy moth population is suppressed.

There are a number of complications. First, the substance we use to disrupt gypsy moth mating communication is not (+)-disparlure, but what is known as "racemic" -disparlure. Racemic-disparlure is a 50:50 mixture of (+)-disparlure and a mirror-image molecule we call (-)-disparlure. We use racemic-disparlure rather than (+)-disparlure because it is far cheaper, and tests indicate that it does as well as (+)-disparlure in disrupting mating communication.

A second complication concerns formulating the pheromone. The mating season for the gypsy moth occurs over a 3-to-6 week period in mid-summer. For the mating disruption technique to be effective, the pheromone must be formulated in such a way that it is slowly and constantly released so that it

permeates the air in the woodlot for the entire mating season. The formulation must also be weather resistant. Much of the research since 1971 has concentrated on the development and field testing of numerous candidate formulations. To date, the three most promising formulations include a microcapsule formulation, a hollow fiber formulation, and a laminated plastic formulation. This last formulation has been registered with the EPA as a mating disruptant and is available commercially in two formulations, an aerially dispersed formulation called "Disrupt™," and as a ground-applied system called "Luretape™." There is some question as to the utility of these products, and where they should be used.

The mating disruption technique is thought to be density dependent; that is, the effectiveness of the approach should increase as the gypsy moth population level decreases. This may be because male gypsy moths can locate females visually as well as by following pheromone plumes. Current theory has it that a male orients to females primarily by pheromones at low population densities, but visual location is more important at high population densities, although the processes of mating behavior have still not been thoroughly elucidated. Hence, most disruption studies have been conducted at low population densities.

Mating communication disruption can be measured by placing pheromone-baited male traps in treated plots and comparing catches with that obtained in untreated plots. Unless population densities are known to be similar in all plots, these catches must be normalized against some measure of relative pest population. If normalized male-trap catch in treated plots average one per trap, while those in untreated plots average 10 per trap, then one can calculate that there was a 90% reduction in mating communication

disruption. (It should be pointed out that "mating communication disruption" is quite different from "mating disruption.") If the above traps had been females, all would have been mated, so that 90% mating communication disruption would translate into 0% actual mating disruption. On the other hand, if the control plots had 10 males per trap, while the treated plots had 0.1 male per trap, communication disruption would be 99% while mating disruption would be up to 90%. Looking at it another way, if the "control" traps averaged 1 male, while the "treated" traps averaged 0.1 males, then there would be 90% mating disruption and 90% communication disruption. Thus, less communication disruption is needed at low population levels to achieve actual mating disruption, while the effects of higher populations can be overcome by increasing the level of communication disruption by increasing the dose.

In 1980, a study was conducted in Cecil County, Maryland, to determine when mating communication disruption translates to actual mating disruption, leading to the suppression of natural gypsy moth populations. Racemic-disparlure, formulated in Hercon® flakes, was aerially applied to 40 acre oak-forest plots at 3 rates using equipment designed by the Animal Plant Health Inspection Service. Monsanto RA 1990 was added as a sticker. Achieved rates were 3, 12, and 30 g/acre. Four blocks were treated at each rate, with four other blocks left untreated as controls. Gypsy moth larval population levels in the blocks had been assessed during the spring by banding 50 host trees in each block with burlap-band larval traps. This was used as our measure of relative population pressure in the blocks. The blocks were rank-ordered from lowest to highest population, and divided into four population classes, with one block from each class assigned to each treatment,

giving a range of population levels for each dose. Each block was divided in two, with half the block receiving a grid of 12 female mating stations, while the other half of each block received a grid of 12 male APHIS milk-carton traps baited with 500 micrograms of (+)-disparlure. Mating communication disruption was estimated for each block by normalizing the trap catch against the population measure (number of larvae per block) and by comparing the resulting ratios against similar ratios calculated for the control plots. For instance, for each larva found in the 30 g/acre, an average of .94 males were caught, while in the control blocks an average of 12.08 males were caught for each larva found in the blocks. This was estimated to be 92% mating communication disruption for 30 g/acre compared with 94% and 59% achieved at the 12 g and 3 g dosages.

By comparing the estimated level of communication disruption in each plot with corresponding mating activity of observed females, the conditions governing the translation of communication disruption into actual mating disruption was established. Two types of females were placed out at the mating sites as 1-day-old virgins and returned after 2-day exposure to the feral males in the blocks. One type, termed "wild," developed from field-collected pupae. A second type, called "lab," developed from laboratory-reared pupae. A third type of female termed "feral" was also observed. These were females actually sampled from the plot. Highly significant negative dose-responses were seen for all three female types. Strong correlations were seen between the population of larvae in the plot and mating success of females, especially in the 30 g and control plots. Pre-season and post-season egg mass survey results were consistent with a hypothesis that population suppression occurred due to the use of disparlure

when used in sparse (10 egg mass per acre or less) gypsy moth populations. The results indicate that mating disruption is a function of two factors: the level of communication disruption present in the plot, and the relative population size.

It should be emphasized that at this time we would caution that this technology should not be used against gypsy moth populations higher than 10 egg masses per acre except in a strictly controlled test situation.

II. Use of Gypsy Moth Traps

Several companies are marketing sex pheromone traps designed to catch male gypsy moths. The following points should be understood about these traps.

1. The traps may differ in their efficiency for catching male moths due to:

   a. differences in trap design,

   b. differences in pheromone content of lure and release rates from dispensers,

   c. whether they use (+)-disparlure or racemic-disparlure as bait.

2. These sex pheromone traps may be very useful as a "survey tool" for a community or, indeed, for the individual homeowner. If there are many males caught, the community or homeowner should evaluate his shade trees and woodlots for the presence of high numbers of gypsy moth egg masses, and plan appropriate action the following year. At present, we cannot directly link a given trap catch to a given egg mass/acre estimate. However, a low catch would indicate a reduced risk, while a high catch indicates that an egg mass evaluation is in order.

3. Homeowners or communities in areas of endemic gypsy moth populations, even as low as 10 egg masses per acre, should expect no control benefits from the use of pheromone traps against gypsy moths. Direct control may be expected against extremely sparse populations. The basic concept of the use of male-trapping for direct control is that you must have more traps "calling" than virgin females, or else the males find most of the females before finding the trap. Moreover, the trap must be as potent, or more potent, than a calling virgin female moth for direct control to be achieved. This may be possible with traps using (+)-disparlure, but is less likely for traps using racemic-disparlure. On the other hand, racemic-disparlure may be an ultimately more sensitive survey tool for measuring population levels, but this is still to be determined.

4. Tests in 1981 and 1982 indicate that the USDA "milk carton" trap, baited with 0.5 mg of (+)-disparlure and using dichlorvos insecticide to kill trapped moths, is more attractive than calling virgin gypsy moth females in attracting males, and will catch 50% to 80% of males so attracted. Of the commercial traps evaluated, only the Hercon Single Season Trap®, whose design is similar to the USDA trap, was as efficient as the USDA milk carton trap for catching males. The J. T. Baker "Bag-a-Bug®" gypsy moth trap and the Hercon Multiseason Trap® were as attractive as the USDA trap, but were less efficient in trapping males attracted to them. However, the plastic bodies may make it harder for rodents to penetrate the traps -- a problem with the wax-coated cardboard milk carton-type designs.

5. Homeowners should be aware that, if they touch the pheromone wick, they too may become attractive to male moths. This can be annoying. Amorous males can be driven off by snapping fingers or twigs. The snapping sound, or

"ultrasound," apparently signals the male moths that a bat is approaching.

In summary, gypsy moth sex pheromone traps may be useful as survey or monitoring devices, but direct control cannot be achieved in areas of moderate-to-high populations through their use.

III. The Use of Bacillus thuringiensis

Several formulations of Bacillus thuringiensis, or B.t., are registered for the suppression of gypsy moth populations. It is the material of choice for some states. Used in the proper situations it gives good results. It will seldom totally eliminate a gypsy moth population from a plot, and under some circumstances its use can do more harm than good. The following should be kept in mind when using B.t. against gypsy moths.

1. When used in its formerly recommended manner, that is, two applications of 8 BIU's per season, it is considerably more expensive than registered alternatives that need only one application. Moreover, the requirement for two applications imposes severe scheduling problems for state programs. Fortunately, recent research results indicate that one application at 12 BIU's (Billion International Units) will give as good control as two applications of 8 BIU's at a price equivalent to that of Sevin®, Dylox®, or Orthene®.

2. B.t. must be applied after the gypsy moth caterpillars emerge, when the trees have begun to foliate, and before the caterpillars reach the fourth instar. This makes for a relatively narrow window that varies from place-to-place within a state according to latitude, longitude, altitude, and northern vs southern exposure. Research is ongoing to determine whether B.t.

at higher rates can control older caterpillars, but this is uncertain at this time.

3. In order to effect the hoped-for biological response, B.t. must be properly applied. Sprays should never be made in winds greater than 10 mph. Moreover, on a cool sunny day in May, the ground warms before the air, causing thermal layers that prevent the aerially applied B.t. from reaching its intended site. Thus, spraying often should be halted by mid-morning even on calm clear days. Spray conditions during May are often unfavorable for the application of B.t., sometimes leading to its application on fourth instar gypsy moth.

4. When applied to fourth instar gypsy moth caterpillars, B.t. may kill just enough caterpillars to prevent the natural collapse of a defoliating population without providing adequate foliage protection. Moreover, the use of B.t. against extremely large populations, even when properly applied against the right aged caterpillars, may leave enough caterpillars to strip the trees, but kill enough to prevent natural collapse. Thus, B.t. should not be used against extremely large populations.

5. The use of B.t. does have many advantages. Used against moderate populations (50-1,000 egg masses per acre) it will provide foliage protection and some year-to-year population reduction. It is harmless to bees and gypsy moth parasites, and is certainly the material of choice for use in environmentally sensitive areas such as aquatic habitats.

In summary, B.t. is effective when properly used, and should have a prominent place in the gypsy moth suppression programs of most states. However, operational problems may preclude complete reliance on its use. Used inappropriately, it may prolong rather than shorten gypsy moth outbreaks.

IV. Tree Banding

Many homeowners are attempting to mitigate their gypsy moth problem through the use of tree banding. Three basic techniques exist: shelter bands, insecticide-treated bands, and sticky barrier bands.

A. Shelter Bands. During the late instars, gypsy moth caterpillars descend from the trees during the day (to avoid predation ?) and return to feed at night. Tree-to-tree movement of gypsy moths commonly occurs in high populations. If burlap or rag bands are tied around infested trees, many caterpillars will choose to rest under them. Boards, tar paper, signs, etc. are also used for shelter. Many homeowners will band all their shade trees, then each day they will collect and destroy all caterpillars, pupae, adults, or egg masses so found. Possibly there are situations where this will provide a degree of protection. However, many have found this method discouraging, possibly for one or more of the following reasons:

1. In high population, the gypsy moths may be numerous enough to strip the trees in the third and early fourth instars, before significant numbers of caterpillars have chosen to descend the trees.

2. Again in high populations, many older caterpillars, perhaps sensing overpopulation, will feed day and night rather than descending during the day.

3. Many homeowners cannot or will not devote the time needed to remove the caterpillars each day. Moreover, gypsy moth life stages have allergenic hairs that can cause susceptible individuals to develop rashes.

4. We have not established what percentage of the total gypsy moth population descends the trees. We think that this varies with tree species,

and within species as well, depending in part on the number of hiding places present high in the tree. For instance, a greater percentage of caterpillars should descend from a young red oak with smooth bark and without broken limbs or other hiding places than will descend from a large white oak with many bark flaps or chestnut oak with deep bark ridges. However, caterpillar behavior has proven to be unpredictable, and more work is needed before flat statements can be made.

On the other hand, shelter bands are potentially useful monitoring tools, and there are possibly many homeowner situations involving smooth-barked yard trees, especially isolated ones with moderate gypsy moth populations, where removing caterpillars from shelter bands may prove useful.

B. Insecticide-Treated Bands. In principle, this is a variant of the shelter bands except that an insecticide "removes" the caterpillars rather than the homeowner. In theory, the caterpillars receive a lethal dose of insecticide as they climb over the band, and as such these bands should be useful in preventing intertree movement of early instar caterpillars.

The problems are the same as stated for the shelter bands; that is, not enough caterpillars may come to the bands to make a difference. The one commercial insecticidal band evaluated at Beltsville in 1982 failed to kill caterpillars. Apparently it was marketed without proper field testing. Thus, the consumer should monitor any such tape to be sure that it is performing as advertised.

C. Sticky or Slick Barrier Bands. Several companies are marketing bands purported to keep gypsy moth caterpillars from crossing. The following points should be considered.

1. The bands will not protect trees already bearing gypsy moth egg masses. Caterpillars from these masses (providing they do not balloon off) will tend to be kept in the tree by the bands.

2. The bands will not prevent first instar caterpillars from ballooning onto the trees. Again, these caterpillars will tend to be kept on the tree by the bands.

3. The bands may be useful in preventing uninfested trees, especially trees treated with pesticides, from being infested (or reinfested) by caterpillars moving in from nearby infested, untreated trees. Of course, this assumes that the product does what it claims, that is, prevents the caterpillars from crossing. Unfortunately, none of the seven bands or sticky agents evaluated at Beltsville in 1982 successfully prevented caterpillars from crossing.

4. Sticky bands have been used in the past to protect uninfested trees or trees from which egg masses had been removed. Much of this work was summarized in a 1920 publication by C. W. Collins and C. E. Hood (Gypsy Moth Tree-Banding Material: How to Make, Use, and Apply It - USDA Bulletin No. 899). Apparently we need to relearn how to effectively make and use such bands.

V. Egg Mass Treatments

Products have appeared on the market to deal with gypsy moth egg masses. These include insecticidal treatments and scrapers. The destruction of egg masses certainly will not effect gypsy moth population dynamics over a broad area, but there are certainly local situations where egg mass destruction can

be useful in certain years. Egg masses are present nine months a year and can be destroyed at leisure. Moreover, destruction of large concentrations of egg masses can reduce the blowout of ballooning first instar caterpillars into areas of light infestation. The following should be considered:

1. If egg masses are to be scraped, they should be scraped into plastic bags of an appropriate size and destroyed by burning or burying. Placing them in a freezer will not destroy them. Any egg falling to the ground can still hatch. Several problems are associated with scraping egg masses:

a. The egg masses are coated with allergenic hairs from the female's abdomen, and can cause rashes to susceptible individuals.

b. Many egg masses occur high in the tree. There is a significant risk of injury to persistent scrapers who climb after such egg masses without adequate thought or preparation.

c. Many egg masses are hidden on the tree or on the ground in litter around the tree, and may provide enough survivors to strip a tree. Also, first instar caterpillars can balloon to cleared trees, or older caterpillars can crawl from neighboring uncleared trees or woodlots. Thus, a program of egg mass destruction combined with an effective banding program might be in order.

2. Destruction of egg masses through the use of ovicides is a possibility. The following should be considered:

a. The traditional use of creosote should probably be discouraged due to evidence that creosote is a weak carcinogen.

b. Pesticides are being marketed in small bottles marked for use against gypsy moth egg masses. These bottles are generally poorly labeled

(typically only the chemical name, such as Dimethyl (2,2,2-trichloro-1-hydroxyethyl) phosphonate, is given, and the product is called "XYZ Gypsy Moth Egg Mass Killer"). This is probably an expensive way to buy trichlorfon, or Dylox™, and more importantly in the event of accident, critical delays might occur while poison control centers tried to ascertain exactly with what active ingredient they are dealing.

c. Pesticides that are to be painted onto, or squirted onto, or aerosoled onto egg masses have the same drawbacks as scrapers, in that many egg masses will be hidden or out of reach.

d. Various soaps, surfactants, and pine oil products have looked promising in tests and may be useful alternatives to pesticides for egg mass destruction.

e. Compounds that can be sprayed on egg masses with power equipment could be useful in community IPM programs.

3. In years when high winds occur during egg hatch, and large numbers of egg masses occur over a wide area, strategies based on egg mass destruction will be ineffective due to the widespread ballooning of larvae.

IV. Homeowner Options for Control of Gypsy Moth Caterpillars Using Pesticides

1. If it has been determined that defoliating levels of gypsy moths are present in a forested community, then the cheapest and most effective method for dealing with the problem, assuming that the use of pesticides for such purposes is acceptable to the community-at-large, is for the individual homeowners to band together, and working with the state or local government, contract for the aerial application of a registered insecticide over the

entire community. An advantage to this is that the per acre volume of pesticide is far less by this method than for ground application of the same pesticide.

2. If joint action is not taken, then the individual homeowner can use heavy duty high-pressure sprayers to protect his trees, or, more likely, hire a commercial applicator with the proper equipment to do the job. Currently registered pesticides lack the residual life necessary to prevent reinfestation of treated properties from neighboring untreated lots; however, some of the new synthetic pyrethroid pesticides have such residual life, and show promise of providing season-long protection with one application of pesticide.

3. Pesticides are being sold to homeowners to control gypsy moth caterpillars using hose-end sprayers. This will only protect shrubs and very small trees. It is a useless method where even moderately-sized shade trees are involved.

4. Trunk injection of insecticides is a useful technique to provide protection for individual large shade trees.

Ed. note: Since this technique causes wounds to the tree, some simple precautions should be used. Inject or implant insecticides only in healthy, vigorous trees. Use a sharp bit to make the hole, and do not make the hole any wider or deeper than necessary, but deep enough for the implant to be inserted just beneath the cambium layer.

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife--if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

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